

WHAT IS CLAIMED IS:

1. A light-weight golf club shaft comprising:
a first angled layer;
a first straight layer formed on said first angled layer;
a second angled layer formed on said first straight layer;
a second straight layer formed on said second angled layer;
said shaft having a length along a longitudinal direction;
each of said layers extend over said length of said shaft and includes fiber-reinforced composite material, said fiber-reinforced composite material containing reinforcing fibers;
said reinforcing fibers of said second angled layer being oriented at an angle relative to said longitudinal direction of said shaft; and
said second angled having at least one of said angle and a thickness effective provide said shaft with a torsional strength of at least 120 kgf×m×degrees and a weight of from 30 to 40 g.
2. A light-weight golf club shaft according to claim 1, wherein said reinforcing fibers of said second angled layer are oriented at an angle in a range of from 35 to 75 degrees relative to said longitudinal direction of said shaft.
3. A light-weight golf club shaft according to claim 1, wherein said reinforcing fibers of said second angled layer are oriented at an angle in a range of from 60 to 75 degrees relative to said longitudinal direction of said shaft.
4. A light-weight golf club shaft according to claim 1, wherein said reinforcing fibers of said second angled layer are oriented at an angle in a range from 65 to 70 degrees relative to said longitudinal direction of said shaft.

1 5. A light-weight golf club shaft according to claim 1, wherein said layers
2 are effective to provide said shaft with a crushing strength of at least 10 kg/10
3 mm.

1 6. A light-weight golf club shaft according to claim 1, wherein:
2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range of from 35 to 75 degrees relative to said longitudinal direction of said
4 shaft; and

5 said layers are effective to provide said shaft with a crushing strength of
6 at least 10 kg/10 mm.

1 7. A light-weight golf club shaft according to claim 1, wherein:
2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range of from 60 to 75 degrees relative to said longitudinal direction of said
4 shaft; and

5 said layers are effective to provide said shaft with a crushing strength of
6 at least 10 kg/10 mm.

1 8. A light-weight golf club shaft according to claim 1, wherein:
2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range from 65 to 70 degrees relative to said longitudinal direction of said
4 shaft; and

5 said layers are effective to provide said shaft with a crushing strength of
6 at least 10 kg/10 mm.

1 9. A light-weight golf club shaft according to claim 1, wherein said
2 second angled layer has a thickness in a range of from 0.04 to 0.1 mm.

1 10. A light-weight golf club shaft according to claim 1, wherein:
2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range of from 35 to 75 degrees relative to said longitudinal direction of said
4 shaft; and

5 said second angled layer has a thickness in a range of from 0.04 to 0.1 mm.

1 11. A light-weight golf club shaft according to claim 1, wherein:
2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range of from 60 to 75 degrees relative to said longitudinal direction of said
4 shaft; and

5 said second angled layer has a thickness in a range of from 0.04 to 0.1 mm.

1 12. A light-weight golf club shaft according to claim 1, wherein:
2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range of from 65 to 70 degrees relative to said longitudinal direction of said
4 shaft; and

5 said second angled layer has a thickness in a range of from 0.04 to 0.1 mm.

1 13. A light-weight golf club shaft according to claim 1, wherein:
2 said layers are effective to provide said shaft with a crushing strength of
3 at least 10 kg/10 mm; and

4 said second angled layer has a thickness in a range of from 0.04 to 0.1 mm.

1 14. A light-weight golf club shaft according to claim 1, wherein:
2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range of from 35 to 75 degrees relative to said longitudinal direction of said
4 shaft;

5 said layers are effective to provide said shaft with a crushing strength of
6 at least 10 kg/10 mm; and

1 said second angled layer has a thickness in a range of from 0.04 to 0.1 mm.

1 15. A light-weight golf club shaft according to claim 1, wherein:

2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range of from 60 to 75 degrees relative to said longitudinal direction of said
4 shaft;

5 said layers are effective to provide said shaft with a crushing strength of
6 at least 10 kg/10 mm; and

7 said second angled layer has a thickness in a range of from 0.04 to 0.1 mm.

1 16. A light-weight golf club shaft according to claim 1, wherein:

2 said reinforcing fibers of said second angled layer are oriented at an angle
3 in a range of from 65 to 70 degrees relative to said longitudinal direction of said
4 shaft;

5 said layers are effective to provide said shaft with a crushing strength of
6 at least 10 kg/10 mm; and

7 said second angled layer has a thickness in a range of from 0.04 to 0.1 mm.

1 17. A light-weight golf club shaft according to claim 1, wherein:

2 said shaft has a small-diameter end and a large-diameter end;

3 said first angled layer has a first thickness near said small-diameter end of
4 said shaft;

5 said first angled layer has a second thickness near said large-diameter end
6 of said shaft; and

7 said first thickness is substantially twice said second thickness.

1 18. A light-weight golf club shaft according to claim 1, wherein said
2 reinforcing fibers include organic, inorganic and metal reinforcing fibers.

1 19. A light-weight golf club shaft, said shaft having a length along a
2 longitudinal direction, comprising:

3 a first angled layer;

4 a first straight layer formed on said first angled layer;

5 a second angled layer formed on said first straight layer;

6 a second straight layer formed on said second angled layer;

7 each of said layers extend over said length of said shaft and include fiber-
8 reinforced composite material, said fiber-reinforced composite material containing
9 reinforcing fibers;

10 said reinforcing fibers of said second angled layer oriented at an angle in
11 a range of from 35 to 75 degrees relative to said longitudinal direction of said
12 shaft;

13 said second angled layer has a thickness in a range of from 0.04 to 0.1 mm;

14 said shaft has a small-diameter end and a large-diameter end;

15 said first angled layer has a first thickness near said small-diameter end of
16 said shaft;

17 said first angled layer has a second thickness near said large-diameter end
18 of said shaft;

19 said first thickness is substantially twice said second thickness; and

20 said layers are effective to provide said shaft with a torsional strength of
21 at least $120 \text{ kgf} \times \text{m} \times \text{degrees}$ and a weight of from 30 - 40 g.

1 20. A method for forming a golf club shaft around a mandrel having a
2 length along a longitudinal axis, the steps comprising:

3 forming a first reinforcement layer from a first fiber material, said first
4 fiber material having fibers aligned along a single direction;

5 *sub 1* forming a first angled layer from second and third fiber material, said
6 second and third materials having fibers aligned along a single direction;

7 bonding said second and third materials together to form said first angled
8 layer, such that said fibers of said second material form a first angle with said
9 fibers of said third material;

10 forming a first straight layer from a fourth fiber material, said fourth fiber
11 material having fibers aligned along a single direction;

12 forming a second angled layer from fifth and sixth fiber material, said fifth
13 and sixth materials having fibers aligned along a single direction;

14 bonding said fifth and sixth fiber materials together to form said second
15 angled layer, such that said fibers of said fifth and sixth material form a second
16 angle in the range of from 70-150 degrees and said second angled layer has a
17 thickness in the range of from 0.04 to 0.1 mm;

18 forming a second straight layer from a seventh fiber material, said seventh
19 fiber material having fibers aligned along a single direction;

20 forming a second reinforcement layer from an eighth fiber material, said
21 fiber material having fibers aligned along a single direction;

22 wrapping said first reinforcement layer around said mandrel such that said
23 fibers of said first reinforcement layer are aligned 90 degrees with respect to said
24 longitudinal axis;

25 wrapping said first angled layer around said first reinforcement layer such
26 that said first angle of said fiber material of said first angled layer is bisected by
27 said longitudinal axis;

28 wrapping said first straight layer around said first angled layer such that
29 said fibers of said first straight layer are aligned with said longitudinal axis;

30 *Sub 17* wrapping said second angled layer around said first straight layer such that
31 said second angle of said fiber material of said second angled layer is bisected by
32 said longitudinal axis;
33 wrapping said second straight layer around said second angled layer such
34 that said fibers of said second straight layer are aligned with said longitudinal axis;
35 wrapping second reinforcement layer around said second straight layer to
36 form a layered wrap, such that said fibers of said second reinforcement layer are
37 aligned with said longitudinal axis;
38 curing said layered wrap in an oven to form a cured shaft;
39 removing said mandrel from said cured shaft; and
trimming ends said cured shaft to produce said golf club shaft.

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